Comments on NRC Committee report Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles, Phase 2

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These comments address the Safety sections in Chapters 6 (pages 6-35 to 6-40) and 10 (pages 10-7 to 10-9).

The draft report summarizes the findings conducted by researchers at the National Highway Traffic Safety Administration (NHTSA), Lawrence Berkeley National Laboratory (LBNL), and Dynamic Research, Inc. (DRI) on the recent historical relationship between vehicle weight/size and U.S. societal fatality risk per vehicle miles of travel (VMT). The draft report contains several errors in the reported findings of these three organizations, and attributes some findings to the wrong organization.

The draft report refers to one NHTSA report from 2012, DOT HS 811 666 (NHTSA 2012b). However, this report summarizes the EDAG/Electricore analysis using computer-assisted engineering. I believe the committee intended to refer primarily to the 2012 NHTSA report DOT HS 811 665, the statistical analysis of recent historical data by Chuck Kahane (NHTSA 2012a). Similarly, the draft report refers to Wenzel 2010; the analysis in that report has been superceded by the 2012 LBNL Phase 1 and Phase 2 reports (LBNL 2012a, LBNL 2012b). Finally, the report refers to analyses by DRI, and cites two DRI reports (from 2004 by Kebschull et al., and from 2008 by Kebschull and Sekiguchi). DRI published three preliminary reports in 2012, which were finalized in 2013: the first attempts to reconcile the differences between the NHTSA and DRI regression models in their 2003 reports (DRI 2013a); the second updates the DRI analysis using its two-stage regression model that simultaneously estimates the effect of mass or footprint reduction on crash frequency (crashes per VMT) and crashworthiness (fatality risk per crash) (DRI 2013b); the third tests the sensitivity of NHTSA's induced exposure sample, based on non-culpable vehicles in 10 states, using a subset of stopped vehicles in 10 states; and examines the effect of separating footprint into its two components, wheelbase and track width (DRI 2013c).

LBNL published a draft report in 2013 that applies the DRI two-stage simultaneous regression model in DRI 2013b and DRI 2013c, using all police-reported crashes in 13 states. Here is a summary of the salient conclusions from each report:

1. NHTSA 2012a (Kahane). Baseline regression model of effect of mass or footprint reduction on societal fatality risk per VMT; 11 sensitivity regressions suggested by LBNL, DRI, and others.
2. LBNL 2012a (Wenzel). Replicates NHTSA baseline regression model and 11 sensitivity regressions in ref. 1; analyzes 8 additional sensitivity regressions.
3. LBNL 2012b (Wenzel). Repeats analyses of ref. 2 using fatality and serious injury crashes from 13 states; separately estimates effect of mass or footprint reduction on crash frequency per VMT and on fatality or casualty risk per crash.
4. DRI 2013a (Van Auken and Zellner). Reconciles the differences between the 2003 NHTSA and 2003 DRI regression analyses, using a one-stage regression model of the effect of mass or footprint reduction on fatality risk per VMT, as well as a two-stage regression model that

simultaneously estimates the effect of mass or footprint reduction on crash frequency (crashes per VMT) and crashworthiness (fatality risk per crash).
5. DRI 2013b (Van Auken and Zellner). Updates the analysis in ref. 4 using the database analyzed in ref. 1 and ref. 2, using the one- and two-stage models described in ref. 4.
6. DRI 2013c (Van Auken and Zellner). Tests the sensitivity of the results in ref. 1 and 5 using a subset of NHTSA's induced exposure sample, stopped vehicles rather than non-culpable vehicles, from crash data from 10 states.
7. LBNL 2013a (Wenzel). Applies the DRI two-stage simultaneous regression model in ref. 5 and 6 using all police-reported crashes in 13 states.

LBNL summarized the results of all these studies in a presentation made to the NRC Committee on June 13 in Washington DC (LBNL 2013b). Finally, LBNL published a draft report analyzing the effect of adding several additional vehicle and driver variables on the estimates of the relationship between mass reduction and crash frequency (LBNL 2014).

Detailed comments on the draft report:

Page 6-35

Line 10: The text in brackets needs to be inserted.

Lines 19 to 21: The NHTSA 2012a report only estimates the effect of mass or footprint reduction on societal fatality risk per VMT; only studies by DRI and LBNL (DRI 2013a, DRI 2013b, DRI 2013c, LBNL 2012b, LBNL 2013a) have estimated the separate effects of mass or footprint reduction on the two components of risk per VMT, crash frequency per VMT and risk per crash.

Line 24: "driver behavior has long been recognized as the single biggest factor" Not sure NHTSA 2012a actually made this statement.

Line 29: Determining crash rates by driver age requires estimates of VMT by driver age. Section 1.6 in NHTSA 2012 uses a regression model of crash culpability to demonstrate that drivers of either gender under 30 or over 70 are more likely to be at fault in a two-vehicle crash than drivers between the ages of 30 and 70.

Line 30: "Considerable variation within this group": do you mean variation in crash rates among young males? Of course some young males are never involved in a crash, and some are involved in multiple crashes. In any event, Wenzel 2010 does not support these statements.

Page 6-36

Lines 2-3: LBNL 2010 did not "demonstrate a correlation between lighter vehicles and younger drivers." The Committee might be referring to LBNL 2011 (revised in March 2012), which showed that vehicles driven by young males involved in fatal crashes had higher "bad driver" ratings than vehicles driven by non-young males, across all vehicle types. (NHTSA developed the bad driver rating in its 2003 report, based on whether alcohol, drugs, or reckless driving was involved in the current crash, as well as the driver's driving record over the last three years.)

While LBNL has demonstrated a correlation between driver age and bad driving behavior, it has not demonstrated a correlation between vehicle mass and driver age.

Lines 7-8: Suggest you replace "is poorly measured" with "is not measured". Change in velocity (delta V) is reported only in the NASS Crashworthiness Data System (CDS) database, and is estimated based on the amount of crush observed in the vehicle(s). The FAS database used for the NHTSA, LBNL, and DRI analyses does not estimate delta V. Some states report crash speed in their databases, but these data are not considered reliable. Theoretically pre-crash vehicle velocity could be obtained from event data recorders in vehicles; however, these data are rarely made publicly available. The NHTSA, LBNL, and DRI regression models use posted speed limit as a crude proxy for crash severity.

Line 16: This reference needs to be included.

Line 30, "vehicle design": That is not the conclusion of LBNL 2012a. LBNL 2012a concluded that after accounting for vehicle attributes, driver characteristics, and crash circumstances, there still is a large range in fatality risk per VMT among vehicle models of similar mass. It is not clear whether this range is due to differences in vehicle design or how vehicles are driven.

Line 31 and lines 1-2 of page 6-37: None of the recent NHTSA, LBNL, or DRI regression analyses include seat belt use, since this is often self-reported by crash survivors and generally determined to be unreliable. LBNL 2012a demonstrated that the baseline NHTSA regression models suggest that other vehicle attributes, driver characteristics, and crash circumstances have a much greater effect on fatality risk than a reduction in vehicle mass or footprint:

> "Note that the three vehicle variables of interest, UNDRWT, OVERWT, and FOOTPRINT, all have a much lower estimated effect on risk than almost all of the control variables in Figure 2.5. For instance, a 100-lb reduction in curb weight for an underweight car is estimated to increase risk by 1.55%, while installing ESC would reduce risk by 11.9%; the models estimate that the beneficial effect of adding ESC is nearly ten times that of reducing mass by 100 lbs. The control variables in Figure 2.6 have a much bigger estimated effect on risk than the mass or footprint reduction variables, or the control variables presented in Figure 2.5. Male drivers are estimated to increase US fatality risk per VMT by nearly 40%, while the three control variables for crash environment, NITE, RURAL, and SPDLIM55, are estimated to more than triple fatality risk per VMT. A crash occurring in a high-fatality state carries an estimated 30% higher fatality risk per VMT than a crash in other states."

Page 6-37

Line 2: The NHTSA and DRI reports, and LBNL 2012a, analyze <u>fatality</u> risk. LBNL 2012b is the only one that analyzes <u>casualty</u> risk, which is fatalities plus serious injuries. Suggest changing "occupants of smaller-sized, compared to larger-sized, vehicles are at greater risk of severe injury" to "occupants of lighter vehicles are on average at greater risk of fatality".

Lines 5-6: Suggest changing "vehicle footprint and size have a greater influence" to "vehicle footprint has a greater influence”. Figure 3.3 in LBNL 2012a indicates that, for cars, mass reduction is associated with a higher increase in fatality risk when footprint is simultaneously decreased than when footprint is held constant (and footprint reduction is associated with a higher increase in fatality risk when mass is simultaneously decreased than when mass is held constant).

Lines 6-7: Although it was estimated in the NHTSA baseline regression model, NHTSA 2012a did not report the estimated effect of footprint reduction on fatality risk; Figure 3.3 in LBNL 2012a indicates that mass and footprint reduction are associated with a higher increase in fatality risk for cars than mass reduction while holding footprint constant. The same figure suggests that a 1-square foot reduction in car footprint is associated with a larger increase in fatality risk than a 100-lb reduction in mass of lighter-than-average cars.

Line 8: Suggest changing “is likely to have less crush distance than it had before the footprint was reduced” to “is likely to have less crush distance to absorb crash forces, and may increase the propensity for a vehicle with a high center of gravity to roll over.”

Lines 9-10: Suggest changing “The DRI studies identified the separate effects of size (track width & wheelbase) and mass” to “The DRI studies estimated the effect of mass reduction while holding footprint constant, and identified the effects of the separate components of footprint, track width and wheelbase, on fatality risk”. The final versions of NHTSA 2012 and LBNL 2012a confirmed DRI’s estimated effect of modeling wheelbase and track width separately from footprint.

Lines 12-13: The purpose of the NHTSA, LBNL, and DRI analyses is to estimate the effect of reducing vehicle mass on societal fatality risk. All three studies suggest that either mass reduction or footprint reduction in cars will increase fatality risk per VMT, of roughly the same magnitude; on the other hand, reducing mass of the heaviest light trucks is estimated to slightly decrease societal fatality risk. See Figure 3.3 in LBNL 2012a.

Line 16: Replace “tire base” with “track width”. Refer to Section 1.6 of NHTSA 2012, and Section 1.1 of LBNL 2012a, for a summary of the expected relationships between vehicle mass, size, and fatality risk.

Lines 18-20: Suggest changing “there appears to be an increase in risk when more mass is removed from lighter cars (below 3100 lbs) than if the same mass is removed from heavier vehicles” to “there appears to be a larger increase in risk when 100 lbs is removed from lighter-than-average cars (below 3106 lbs) than when 100 lbs is removed from heavier cars.”

Suggest you add disclaimer text similar to the following, from LBNL 2012a (p. 88):

> “Although the purpose of these statistical studies is to estimate the effect of vehicle mass reduction on societal risk, this is not exactly what the regression models are estimating. Rather, they are estimating the recent historical relationship between mass and risk, after accounting for most measurable differences between vehicles, drivers, and crash times and locations. In essence, the regression models are comparing the risk of a 2600-lb

> Dodge Neon with that of a 2500-lb Honda Civic, after attempting to account for all other differences between the two vehicles, and where and how they are driven. The models are not estimating the effect of literally removing 100 lbs from the Neon, leaving everything else unchanged."

Lines 21-23: Suggest changing "from lighter vehicles appears to maintain safety while improving fuel economy" to changing "from lighter vehicles appears to maintain societal safety while improving fuel economy". NHTSA 2012 simulated four fleetwide mass reduction scenarios (Section 3.6), the most aggressive of which reduces the mass of heavier light trucks by 5.2%, and of all other vehicle types except lighter cars by 2.6%. This scenario would result in a small reduction in societal fatalities.

Lines 24-26: Suggest replacing this sentence with "The DRI studies also separated the two components of fatality risk per VMT, crash probability (crashes per VMT) and crash outcome (fatalities per crash), and found that, for lighter-than-average cars, mass reduction is associated with a large increase in crashes per VMT but a small decrease in fatalities per crash, leading to a net increase in fatalities per VMT." This is shown in slide 24 of LBNL 2013b.

Lines 27-28: NHTSA argues that the DRI coefficients for fatality risk per crash do not account for crash severity, based on the estimated positive coefficients for male and younger drivers, who are more robust and likely to survive a crash than female or old drivers, and driving at night, which should have little effect on fatality risk once a crash has occurred. Another possible explanation for the unexpected results is differences in crash reporting across states or vehicle types. Collisions of heavier or larger vehicles may be somewhat less likely to be reported because these vehicles are somewhat less prone to damage; on the other hand, collisions of lighter or smaller vehicles may be less likely to be reported if their drivers are less likely to be insured.

NHTSA concludes that the DRI two-stage regression model does not cleanly separate the effects of crash avoidance from crashworthiness (NHTSA 2012 Section 4.6), and that the DRI model suffers from spurious correlation. However, NHTSA believes that this problem does not affect their baseline model of fatality risk per vehicle miles of travel, which combines the effects of mass reduction on crash frequency and fatality risk per crash.

DRI admits that the reasons for the association of mass reduction with a decrease in fatalities per crash are not well understood. They suggest that this association may be due to "an equalizing effect of crash based Safety Standards, NCAP tests, IIHS tests, star ratings, and intelligent vehicle design" that have resulted in vehicle designs that mitigate the theoretical safety penalty in lighter vehicles.

In his comments on the DRI and LBNL preliminary reports, David Greene concurs with NHTSA's conclusion that the DRI model suffers from spurious correlation, but argues that the NHTSA baseline model of fatality risk per VMT also suffers from spurious correlation. In fact, he concludes the opposite of NHTSA: that because the crash probability (rather than the crash outcome) results from the two-stage model are biased by the measure of exposure, it is more valuable to separate crash probability from crash outcome (rather than examine fatality risk per

VMT).

Line 28: “corrected other mistakes” is a bit strong.

Line 29: “exclude 2-door vehicles”. DRI, LBNL, and others criticized NHTSA's exclusion of 2-door cars in its 2003 analysis; NHTSA included 2-door cars in its 2012 analysis. NHTSA excluded sporty, police, and four-wheel drive cars, and full-size vans, in its 2012 analysis, in part because these cars tend to be driven in a much more risky manner than most car models. LBNL 2012a ran a sensitivity regression that included these vehicle types: including these types of cars increases the estimated increase (from 1.55% to 1.79%) in fatality risk per VMT from mass reduction in lighter-than-average cars, while including full-size vans increases the estimated decrease (from 0.34% to 0.77%) in fatality risk from mass reduction in heavier-than-average light trucks (see Figure 5.15 in Wenzel 2012a).

Lines 29-31: DRI tested the sensitivity of NHTSA's results by using a subset of non-culpable vehicles, stopped vehicles, as the basis for induced exposure, rather than non-culpable vehicles. Using stopped instead of non-culpable vehicles generally reduces the negative effect of mass reduction on risk; for lighter-than-average cars, the estimated increase in risk from mass reduction is reduced from 1.55% to 0.97%. On the other hand, using stopped instead of non-culpable vehicles greatly increases the estimated effect of footprint reduction on risk, from a 1.87% increase to a 3.43% increase. Replacing footprint with its components wheelbase and track width results in similar reductions in the negative effect of mass reduction, while increasing the estimated risk from footprint reduction. Combining both changes (using stopped instead of non-culpable vehicles, and replacing footprint with wheelbase and track width) estimates a very small, statistically insignificant (0.26%) increase in risk from mass reduction in lighter-than-average cars, and statistically significant decreases in risk from mass reduction in heavier-than-average cars (-0.90%) and heavier-than-average light trucks (-0.97%). Combining both changes estimates a large increase in fatality risk from track width reduction in cars (6.03%) and light trucks (0.90%), and a large increase in fatality risk from wheelbase reduction in CUVs/minivans (1.45%). See Table 5.3 in LBNL 2012a.

LBNL tested the sensitivity of the NHTSA results using two different measures of exposure, fatal crashes, rather than total fatalities, per VMT, and registered vehicle-years rather than VMT. Using fatal crashes per VMT as the measure of exposure substantially increases the estimated effect of mass reduction on fatality risk in lighter-than-average (from a 1.55% to a 1.95% increase) and heavier-than-average (from a 0.51% to a 0.89% increase) cars. Using registered vehicle-years as the measure of exposure reduces the estimated fatality risk from mass reduction in lighter-than-average cars (from a 1.55% increase to a 0.93% increase) but increase estimated risk in heavier-than-average cars (from a 0.51% increase to a 2.40% increase). See Figure 5.1 in LBNL 2012a.

For the most part the estimated effects of the NHTSA baseline regression model are in the middle of the estimated effects of 19 alternative regression models, and the effects of the alternative models are within the level of uncertainty of the baseline NHTSA regression model; see slides 11-13 in LBNL 2013b. In the NHTSA baseline model the (positive) mass reduction coefficient is statistically-significant for lighter-than-average cars only; the estimated mass reduction coefficient is positive for 18, and is statistically-significant for 17, of the 19 alternative regressions. While the magnitude of the effect of mass reduction on fatality risk in lighter-than-average cars varies substantially depending on the choice of the measure of exposure, and the data and control variables used, in virtually every case mass reduction is associated with a small increase in fatality risk in lighter-than-average cars.

Page 6-38

Line 5: Suggest replacing "given behaviors are" with "given behavior is".

Line 7-8: "do not provide robust inferences." As discussed above, while the magnitude of the effect of mass reduction on fatality risk in lighter-than-average cars varies substantially depending on the choice of the measure of exposure, and the data and control variables used, in virtually every case mass reduction is associated with a statistically-significant small increase in fatality risk in lighter-than-average cars.

Lines 9-10: Suggest replacing "Studies by DRI, Inc. have been far more successful in this regard than the studies by NHTSA" with

> "DRI and LBNL suggested and conducted 19 sensitivity analyses to test the robustness of the baseline NHTSA regression model. For the most part the effects estimated by the NHTSA baseline regression model are in middle of the effects estimated by the 19 alternative regression models, and the effects of the alternative models are within the level of uncertainty of the baseline NHTSA regression model. In the NHTSA baseline model the (positive) mass reduction coefficient is statistically-significant for lighter-than-average cars only; the estimated mass reduction coefficient is positive for 18, and is statistically-significant for 17, of the 19 alternative regressions. While the magnitude of the effect of mass reduction on fatality risk in lighter-than-average cars varies substantially depending on the choice of the measure of exposure, and the data and control variables used, in virtually every case mass reduction is associated with a small increase in fatality risk in lighter-than-average cars."

Lines 14-19: Suggest replace text for item 1 with:

> "1. In its 2003 study DRI separated the effects of footprint and weight on fatality risk. In a 2010 study NHTSA updated its 2003 results including both mass and footprint in the same regression model. In the 2012 studies NHTSA, DRI, and LBNL used analysis of variance inflation factors to demonstrate that including both footprint and weight in the same regression model would not produce inaccurate results. The 2012 studies indicate that mass reduction while holding footprint constant is associated with a small increase in risk for lighter-than-average cars only; the estimated effect on other vehicle types is not statistically-significant.
> 2. The DRI analyses separated the effects of fooprint and weight on crash probability as distinct from crash outcome, using a two-stage regression model. (The term "crash probability" is used here as a more neutral term than "crash avoidance". "Crash

outcome" is used as a more neutral term than "crashworthiness".) This resulted in the inference…"

Lines 22-24: While DRI admits that the relationship between mass reduction and crash outcome (not "probability", as in text) is not well understood, they do not suggest that the correlation is spurious; rather, they suggest that many years of regulations and crash testing have resulted in vehicle designs that mitigate the theoretical safety penalty in crash outcomes in lighter vehicles.

Page 6-39

Line 8: "The crash outcome regression coefficients were not strongly affected by the (change in) exposure measure… " except for mass reduction in heavier-than-average cars (which changed from a 0.42% increase to a 0.11% decrease in fatalities per crash), and footprint reduction in lighter cars (from a 0.12% increase to a 0.52% increase) and heavier cars (from a 0.07% increase to a 0.46% increase); see Tables A-2 and A-4 in DRI 2013c.

Lines 10-11: "In contrast, the crash probability regressions exhibit greater variability across data sets and model formulations…" particularly for mass reduction in lighter cars (from a 1.96 increase to a 1.45% increase), and footprint reduction in lighter cars (from a 1.36% increase to a 1.86% increase) and heavier cars (from a 1.32% increase to a 1.82% increase); see Tables A-2 and A-4 in DRI 2013c.

The examples above only compare the results from DRI's simultaneous two-stage regression model using the two different measures of exposure. Slides 16 and 17 in LBNL 2013b show that the range in estimates across sixteen alternative regression models for crash outcome (casualty risk per crash, slide 17) are at least as large as the range in estimates for crash probability (crash frequency, slide 16). The estimates in slides 16 and 17 are based on casualties per crash in 13 states only, and are not directly comparable to DRI's estimates, which are based on U.S. fatalities per crash.

Line 11: Suggest changing "between mass, size, and fatalities or injuries" to "between mass, size and fatality risk."

Lines 11-14: Again, NHTSA concludes that the DRI simultaneous two-stage model does not cleanly distinguish between crash probability and crash outcome; this should not be interpreted as NHTSA concluding that the results from its baseline fatality risk per VMT model are biased. And while DRI notes that the reasons for the association of mass reduction with a decrease in fatalities per crash are not well understood, they do not conclude that the estimates from its two-stage model are biased; rather, they suggest that manufacturer improvements in vehicle design, driven by over twenty years of safety regulation, may explain their model's estimates of crash outcomes.

Line 16: "This should be a priority in future research." It would be helpful to have specific recommendations on how to improve the analysis in the future. LBNL recently examined whether including two additional variables accounting for differences in vehicle models, and four additional variables accounting for differences in driver characteristics and behavior, changed the association of mass reduction with increasing crash probability (frequency). Adding each of these five variables independently, or at the same time, did not appreciably change this association. These results suggest that other, more subtle, differences in vehicles and their drivers account for the unexpected finding that lighter vehicles have higher crash frequencies than heavier vehicles, for all three types of vehicles (LBNL 2014).

In its critique of the DRI simultaneous two-stage model NHTSA commented that the model does not include any measure of crash severity (other than the posted speed limit on the roadway on which the crash occurred, which is a very rough proxy). One possibility would be to include the severity of the damage inflicted on each vehicle, or whether the vehicle was towed from the crash scene, as a measure of crash severity; at least one of these variables is included in the FARS database and police-reported crash databases from almost every state.

Line 18: Suggest changing “crush stroke” to “crush space.”

Lines 21-28: I believe that these sentences refer to NHTSA 2012b (DOT HS 811 666); they definitely do not refer to NHTSA 2012a (DOT HS 811 665).

Page 6-40

Line 7: “driver behavior aside, lighter vehicles should be more agile, helping to avoid crashes in the first place.” Table 6 in LBNL 2014 suggests that this is not the case for cars. Of the 13 Consumer Reports braking and handling tests analyzed, braking/handling capability improves with decreasing vehicle mass for only two; for the remaining 9 measures, braking/handling capability diminishes with decreasing vehicle mass.

Line 13: Suggest changing “During the transition period when vehicle masses are being reduced” with “During the transition period when masses of heavier vehicles are being reduced”.

Line 14: Suggest changing “in the distribution of the mass across the vehicle fleet” to “in the distribution of vehicle masses across the vehicle fleet.” In reality the distribution of vehicle masses among the fleet is constantly changing. For example, the median mass of MY00 to MY07 cars is 5% higher than the median mass of MY91 to MY99 cars, while the median mass of MY00 to 07 light trucks is 19% higher than the median mass of MY91 to MY99 light trucks (NHTSA 2012a, p. x). And from MY00 to MY07, the average mass of cars increased 5%, while that of truck-based SUVs increased 16% and that of pickups increased 19% (NHTSA 2012a, p. 6). So a policy that reduces mass in the heaviest pickups, while maintaining mass in lighter cars, is bringing the fleet mass distribution back closer to what it was in the MY90s.

Line 15: NHTSA 2012 simulated four fleetwide mass reduction scenarios (Section 3.6): 100-lb reduction in all vehicles; proportionate (2.6%) mass reduction in all vehicles; mass reduction of 5.2% in heavier light trucks, 2.6% in all other vehicle types except cars, whose mass is kept constant; and a safety-neutral scenario, where mass is reduced 0.5% in lighter cars, 2.1% in heavier cars, 3.1% in CUVs/minivans, 2.6% in lighter light trucks, and 4.6% in heavier light trucks. The most aggressive of these scenarios (reducing mass 5.2% in heavier light trucks and

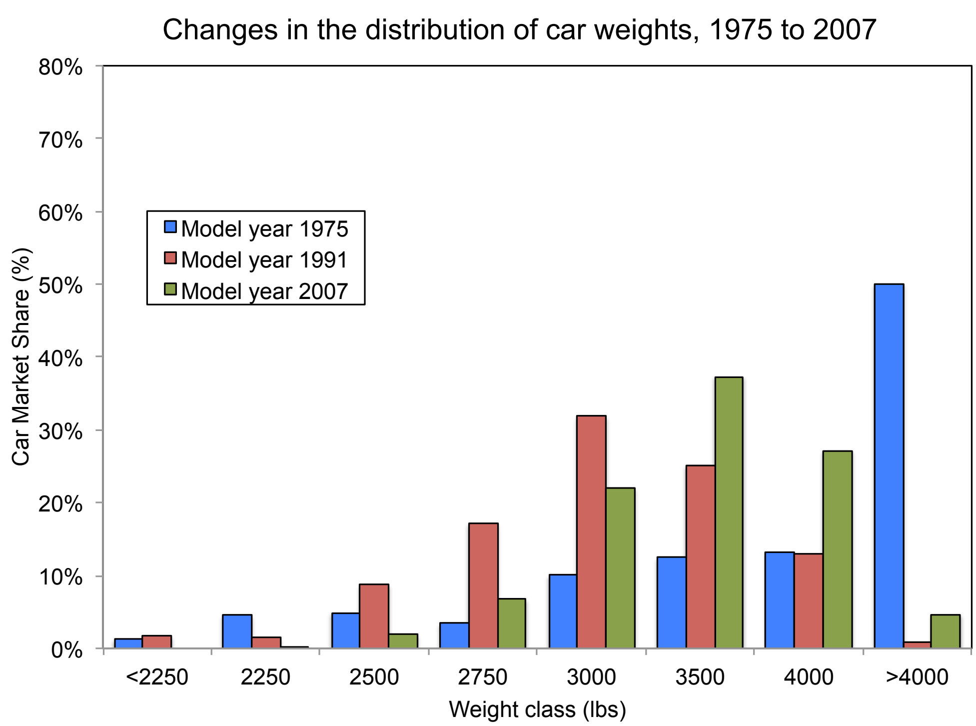
2.6% in all other vehicles types except lighter cars) would result in a small reduction in societal fatalities.

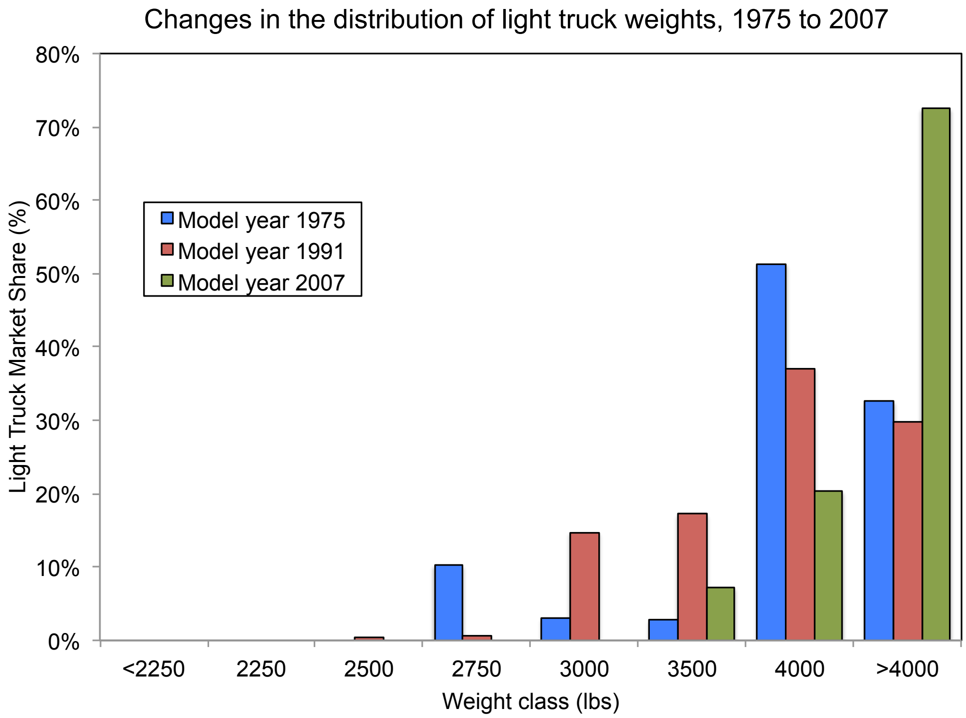
Page 10-7

Lines 29-30: Suggest changing "with the risks for those in the small vehicle increasing with the mass of the larger vehicle (Kahane 1997; Kebschull et al. 2004; NHTSA 2012c; Wenzel 2010)" to "changing "with the risks for those in the lighter vehicle increasing with the mass of the heavier vehicle (Evans 1991; NHTSA 2012a; LBNL 2012a)." Of course this discussion ignores the effect of mass reduction in one-vehicle crashes and rollovers; refer to Section 1.6 of NHTSA 2012, and Section 1.1 of LBNL 2012a, for a discussion of the expected relationships between vehicle weight and size and safety.

Page 10-8

Line 4: Figure 10.2 shows car, not vehicle or car and truck, weights. I assume the years are model years and not calendar years. It would be instructive to plot the mass distribution for cars in model year 2007, and for light trucks in all three model years. The following two figures show the weight distributions through model year 2007, for cars and light trucks; they indicate that vehicle weights continued to increase between 1991 and 2007, and that light trucks are substantially heavier than cars.





Line 13: Suggest removing "even in terms of footprint".

Lines 17-18 : Suggest replacing "isolate the effects of vehicle footprint" to "isolate the effects of reductions in vehicle footprint".

Page 10-9

Line 1: Suggest replacing sentence starting with "To summarize" with "To summarize, all three reports (NHTSA 2012a, LBNL 2012a, and DRI2013b) concur that mass reduction while holding footprint constant is associated with a small increase in risk for lighter-than-average cars only."

Lines 2-4: DRI was the first to include mass and footprint in the same regression model; that is, to estimate the effect of mass reduction on risk while holding footprint constant. In 2010 NHTSA updated their 2003 analysis by including mass and footprint in the same regression model. NHTSA 2012a, LBNL 2012a, and DRI 2013b all include mass and footprint in the same regression model. Suggest changing "First, if mass is held constant, increasing vehicle footprint had a positive effect on societal safety risk" to "Reducing car mass by 100 lbs is associated with a smaller increase in societal fatality risk when footprint is held constant (a 1.55% increase for lighter-than-average cars and a 0.51% increase for heavier-than-average cars) than when footprint is reduced along with mass (a 2.74% increase for lighter-than-average cars and a 1.95% increase for heavier-than-average cars)." See LBNL 2012a, Figure 3.3; NHTSA, DRI, and LBNL all achieved the same results shown in Figure 3.3. Note that Figure 3.3 indicates that reducing car footprint by one square foot while holding mass constant is associated with a larger (1.87%) increase in societal safety risk than reducing car mass 100 lbs while holding footprint constant (1.55% for lighter-than-average cars, 0.51% for heavier-than-average cars).

Lines 4-7: Suggest replacing the sentence starting "The study also notes" with "DRI 2013a, DRI 2013b, LBNL 2012b, and LBNL 2013a indicate that the estimated increase in fatality risk per VMT from mass reduction in the lightest cars is associated with a large increase in crash frequency but a small decrease in risk per crash." Again, NHTSA contends that this result is because DRI did not account for crash severity, or different crash reporting rates by state or vehicle type, resulting in a spurious correlation. DRI admits that the reasons for this result are not well understood, and suggests that manufacturers have designed vehicles that mitigate the theoretical safety penalty of mass reduction.

Lines 8-15: Suggest deleting first two sentences, and replacing the last two sentences with

> "The estimated effects of reducing mass or footprint are small compared to other vehicle attributes, driver characteristics, and crash circumstances (Figures 2.5 to 2.10 of LBNL 2012a). While, on average, mass reduction in lighter-than-average cars is associated with a small increase in fatality risk, there is a large range in risk for cars of the same mass, even after accounting for differences in vehicles, drivers, and crash circumstances (Section 4 of LBNL 2012a). It is important to note that the data used for the statistical analyses rely on historical data from recent vehicle designs, and the mass and size distribution of the fleet, and designs of vehicles, are likely to change by the time the standards become effective in model years 2017 to 2025."

Lines 17-19: Suggest replacing "larger" with "heavier", and remove "to purchase a large vehicle".

Line 20: Suggest replacing "larger" with "heavier".

Line 26: Suggest replacing "are likely to relatively small" with "are likely to be relatively small".

Page 9-33

The legend for Figure 9.8 appears to be incorrect: SUV should be Van, Minivan should be Pickup, Pickup should be SUV, Van should be Minivan.

References

DRI 2013a (Van Auken and Zellner). *Updated Analysis of the Effects of Passenger Vehicle Size and Weight on Safety, Phase I; Updated Analysis Based on 1995 to 2000 Calendar Year Data for 1991 to 1999 Model Year Light Passenger Vehicles.* DRI-TR-11-01-1. Torrance, CA: Dynamic Research, Inc. May.

DRI 2013b (Van Auken and Zellner). *Updated Analysis of the Effects of Passenger Vehicle Size and Weight on Safety, Phase II; Preliminary Analysis Based on 2002 to 2008 Calendar Year Data for 2000 to 2007 Model Year Light Passenger Vehicles to Induced-Exposure and Vehicle Size Variables*. DRI-TR-13-02. Torrance, CA: Dynamic Research, Inc. May.

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